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Does the COVID-19 Pandemic Disproportionately Affect the Poor?
Evidence from a Six-Country Survey

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Abstract
The COVID-19 pandemic has wrought havocs on economies around the world. Yet, much needs to be learnt on the distributional impacts of the pandemic. We contribute new theoretical and empirical evidence on the distributional impacts of the pandemic on different income groups in a multi-country setting. Analyzing rich individual-level data from a six-country survey, we find that while the outbreak has no impacts on household income losses, it results in a 63-percent reduction in the expected own labor income for the second-poorest income quintile. The impacts of the pandemic are most noticeable in terms of savings, with all the four poorer income quintiles suffering reduced savings ranging between 5 and 7 percent compared to the richest income quintile. The poor are also less likely to change their behaviors, both in terms of immediate prevention measures against COVID-19 and healthy activities. We also find countries to exhibit heterogeneous impacts. The United Kingdom has the least household income loss and expected labor income loss, and the most savings. Japanese are least likely to adapt behavioral changes, but Chinese, Italians, and South Koreans wash their hands and wear a mask more often than Americans.

JEL Classification: D00, H00, I1, I3, O1

Key words: COVID-19, poverty, income quintiles, behavior changes

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"An imbalance between rich and poor is the oldest and most fatal ailment of all republics."

Plutarch, Greek historian

I. Introduction

Thanks to improved global living stands, poverty has been steadily on the decline (World Bank, 2018; Ravallion, 2019). Most recently, the international community has set the ambitious goal of eradicating poverty in the next decade.[1] Yet, this undertaking is predicated on a well-functioning economy that yields growth that can be shared among the different population groups. The unexpected arrival of the COVID-19 pandemic has brought most economies around the world to a grinding halt, which is poised to severely disrupt this agenda. Indeed, a recent study predicts that COVID-19-related negative impacts could drive between 80 to under 400 million people into poverty globally (Sumner, Hoy, and Ortiz-Juarez, 2022). To prevent this scenario from occurring, insights into the harmful effects of the COVID-19 pandemic are essential for effective and efficient policies.

Yet, there is little evidence on the distributional impacts of the COVID-19 pandemic on the different income groups in a multi-country setting. Various policy-relevant questions can be raised regarding these impacts. Were the poor more negatively affected by the pandemic than the rich? Specifically, did the poor lose more income? What were the gradients of the impacts for the different income groups? Are the poor more likely to lose income in the future? Were they in a good position to follow medical guidelines in changing their behaviors to protect their health against the pandemic? Would they be in a position to invest more in healthy activities? A good understanding of these issues provides useful inputs for social protection and public health policies

[1] See https://www.un.org/sustainabledevelopment/poverty/.

that can help insure the vulnerable from falling into poverty and protect the poor from sliding further into destitution.

We fill in this gap in the literature and make new contributions both theoretically and empirically in a multi-country setting. On the theoretical front, following Goodman's (1972) seminal health demand model, we incorporate features from the epidemiology literature (e.g., Kermack and McKendrick (1927)) to build a standard utility-maximizing model with heterogeneous healthcare costs. Under our model, individuals pays for different levels of healthcare quality depending on their income. In particular, richer individuals would choose more expensive and higher levels of quality of care. Our model also addresses the issue of endogenously labor supply under the pandemic, where healthy individuals are able to provide more labor supply to increase labor income today but face the risk of becoming infected and hence reduced future labor income. Our theoretical results suggest that the poor are likely to have less savings because of the COVID-19 pandemic. They are also less likely to increase investment in their health, as measured by prevention measures against the pandemic and healthy behavior changes.

These theoretical results are supported by our empirical estimates, which we obtain from analyzing a recent survey that was implemented during the pandemic and covered China, Italy, Japan, South Korea, the United Kingdom, and the United States. Specifically, our empirical results indicate that the poor likely expect labor income loss and are less likely to have savings due to the COVID-19 pandemic. They are also less likely to implement newly-established prevention measures to protect their health, such as keeping a 4-foot physical distance, not touching their face, or covering their mouth when sneezing with a tissue. They are unable to seek medical care when they exhibit early symptoms of the flu. Worse still, they are less likely to afford to change their daily behavior and adjust to the new COVID-19-induced social regulations. They conduct the following healthy activities less: wash hands, wear a mask, eat sufficient fruit and vegetables, and video chat with relatives and friends, and they rely on public transportation more.

Our paper adds to a nascent, but growing, literature on the impacts of the COVID-19 pandemic. The two most relevant studies to ours are Papageorge *et al.* (2021) and Belot *et al.* (2021), which analyze the same survey that we use. While some of our results are consistent with the findings in these studies (e.g., the poorer income quintiles are more likely to suffer income losses compared to the richer income quintiles), our study differs from these studies in several key aspects. First, we explicitly investigate the impacts of the pandemic on the poorer income groups both theoretically and empirically, while these studies offer empirical analyses with a more general focus on other socio-demographic factors. In particular, these studies do not examine the impacts of the pandemic on some outcomes (including individuals' savings) as we do. Second, we offer new analysis of a number of prevention measures against COVID-19 and specific healthy activities that are not examined in these studies.[2] Insights into these health measures can lead to policy relevant advice. Finally, only Belot *et al.* (2021) and we analyze data from all the six countries in the survey while Papageorge *et al.* (2021) focus on data from the United States alone.

Other studies look at the impacts of poverty in the pandemic, but these studies typically either focus on a single country or use more aggregate data than ours. For example, analyzing US county-level data, Wright *et al.* (2020) find that poverty reduces compliance with the COVID-19 shelter-in-place protocols. Another study by Bargain and Aminjonov (2020) examines data at the regional level for 9 countries in Latin America and Africa and finds poverty to reduce work mobility. While these findings are clearly useful, the perspective of individual (or household) decision-making at

[2] Specifically, the prevention measures include keeping 4 ft. distance, not touching one's face, covering one's mouth with a tissue when sneezing, and seeking medical care when developing COVID-19-related symptoms. The healthy activities include eating sufficient fruit and vegetables, taking vitamin, doing exercises, video chat with one's relatives and friends, and use public transportation.

a disaggregated level is arguably most relevant for reducing poverty and inequality, as exemplified by the pioneering works by Angus Deaton (see, e.g., Besley (2016)).[3]

This paper consists of five sections. We offer the theoretical model and estimating equations in the next section before describing the data in Section III. We present the empirical results in Section IV and provide further discussion and conclude in Section V.

II. Analytic Framework and Data

II.1. Theoretical Model

We provide a simple theoretical model based on Grossman's (1972) seminal health demand model to guide our empirical analysis. In Grossman's model, an increase in the number of days that individuals are sick would result in reductions in their labor income and consumption. Our model also addresses the issue of endogenously labor supply under the pandemic. While healthy people can work to increase their labor income today, they face a certain risk of become infected that can reduce their future labor income. Our model also incorporates features from the epidemiology literature (Kermack and McKendrick, 1927) to construct a standard utility-maximizing model with heterogeneous healthcare costs. The cost of healthcare services varies widely depending on the quality of care received and the type of patients.

Following insights from the literature (Arrow, 1963; De Nardi, French, and Jones, 2010), we assume that individuals pays for different levels of healthcare quality depending on their income.[4] In particular, richer individuals would choose more expensive and higher levels of quality of care

[3] Other studies on COVID-19 focus more on related topics of labor market inequality or gender inequality (Cajner *et al.*, 2020; Adams-Prassl *et al.*, 2021; Dang and Nguyen, 2021; Alon *et al.*, 2022). In the absence of appropriate household survey data spanning the pandemic, some studies also employ simulation methods (e.g., Canto *et al.*, 2022) or present descriptive statistics on before-and-after household incomes (Egger *et al.*, 2021). See also Brodeur *et al.* (2021), Miguel and Mobarak (2021), and Bloom *et al.* (2022) for recent review studies on the impacts of the pandemic.
[4] As indicated in Arrow (1963) "*The unusual pricing practices and attitudes of the medical profession are well known: extensive price discrimination by income (with an extreme of zero prices for sufficiently indigent patients*".

such that there is a monotone and increasing relationship between the price of healthcare and income. This implies that in our empirical analysis in the next section, there are five different price levels corresponding to the five income quintiles that individuals can be classified into.[5] This assumption is innocuous and consistent with recent empirical findings. For example, Banerjee (1997) uses waiting time as a screening device to discriminate between rich and poor patients. Analyzing survey data on outpatients HIV in Burkina Faso, Kazianga *et al.* (2015) find that more wealth is positively associated with higher up-front costs, which are defined as any fees that the patient paid at the health facility before seeing a health professional.

Consider an economy where households face a risk of infected disease. Because the dynamics of the epidemic are much faster than the dynamics of the population, the household size is assumed to be constant. Within the household, an individual is either healthy or infected by the diseases. Assuming the household lives for two periods. In time period 0, given an exogenous financial asset *y* and exogenous wage *w*, the household makes a choice on consumption (C_0), healthcare expenditures (*M*), savings (*S*), and labor supply (L_0). In time period 1, the household decides on their labor supply (L_1) and consumption (C_1). More generally, *M* can also represent household investments in health and include healthy activities such as doing exercises or wear a mask.

From the law of motions in the epidemiologic Susceptible, Infectious, or Recovered (SIR) model (see Appendix 1, Part A for more details), we have

$$s_1 = s_0 - \alpha i_0 s_0$$

$$i_1 = i_0 + \alpha i_0 s_0 - \Psi i_0$$

$$r_1 = \Psi \mathrm{i}_0$$

[5] Specifically, we can present the price variable P_j for each income quintile qt_j, for *j*= 1, …, 5. But we suppress the subscript *j* in the subsequent derivations for less cluttered notation.

where s_t is the fraction of healthy individuals, i_t is the fraction of infected individuals, and r_t is the fraction that is recovered from the disease and no longer infectious. The recovery rate is zero at the beginning. A constant population size implies $i_t + s_t + r_t = 1$, (t = 0, 1). The epidemiology parameters are the contact rate α and the recovery rate from the disease Ψ .

We assume labor is inelastically supplied and the infected are unable to work such that

$$L_0 = s_0 = 1 - i_0$$

$$L_1 = s_1 + r_1 = s_0 - \alpha i_0 s_0 + \Psi i_0$$

If healthcare quality is high, people are more likely to recover from the disease. To capture this effect, we endogenize the recovery rate as a function of health expenditure $\Psi(\mathrm{M})$ with $\Psi' = \frac{\partial \Psi}{\partial \mathrm{M}} \geq 0, \Psi'' = \frac{\partial^2 \Psi}{\partial \mathrm{M}^2} < 0.$ [6]

Let ω be the wage which are assumed to be the same for two periods, the labor incomes in periods 0 and 1 are given by

$$Y_0 = \omega L_0$$

$$Y_1 = \omega L_1 = \omega\big(s_0 - i_0 s_0 \alpha + i_0 \Psi(\mathrm{M})\big) = \omega\big(L_0 - (1 - L_0)L_0\alpha + (1 - L_0)\Psi(\mathrm{M})\big)$$

The income loss in period 0 is $D_0 = \omega i_0 = \omega(1 - L_0) = \omega - Y_0$ and the expected income loss in time period 1 is $D_1 = \omega i_1 = \omega(1 - L_1) = \omega - Y_1$.

Let *P* denotes the cost of the healthcare service in terms of the consumption good. Given a non-wage income *y*, the budget constraint at period 0 is given by

$$y + \omega L_0 = C_0 + PM + S.$$

Then the consumption in period 1 is

$$C_1 = xS + Y_1.$$

[6] In Goenka, Liu and Nguyen (2014, 2021, 2022) they modelled Ψ as a function of health capital produced by health expenditure.

where x be the gross rate of return of savings. Thus the consumption in period 1 becomes

$$C_1 = x(y + \omega L_0 - C_0 - PM) + \omega\big(L_0 - (1 - L_0)L_0\alpha + (1 - L_0)\Psi(\mathrm{M})\big).$$

Given all the relevant constraints, assuming the utility function is additively separable over time, the household solves the following problem at period 0

$$\max_{C_0,M,L_0} U(C_0) + V(C_1)$$

Assuming U and V are strictly increasing with concave ($U' > 0, V' > 0, U'' < 0, V'' < 0$) and there exist interior solutions, the first-order conditions yield

$$C\colon U'(C_0) - xV'(C_1) = 0 \qquad (1)$$

$$M\colon (\omega(1 - L_0)\Psi_{\mathrm{M}}(M) - xP)V'(C_1) = 0 \qquad (2)$$

$$L_0\colon (\Psi(\mathrm{M}) - 2\mathrm{L}_0\alpha - x - 1 + \alpha)V'(C_1) = 0 \quad (3)$$

The Hessian of (1)-(3) is required to be negative definite so that the second order conditions satisfy.

Our model yields the following theoretical results.

Proposition 1. *The price of healthcare service decreases the demand for healthcare and labor supply.*

Proposition 2. *The poor's labor income are likely unaffected by the pandemic in the current period, but may be more affected in the next period.*

Proposition 3. *The poor have less savings than the rich in the pandemic.*

Proposition 4. *Given the same risk of infection, the rich are more likely to change their behavior than the poor.*

Note that Proposition 1 is not directly related to the empirical results, but it provides the general result for the other propositions to build on. The proofs for the propositions are presented in Appendix 1, Part A.

II.2. Empirical Model

We estimate the impacts of the COVID-19 pandemic (i.e., the first-order conditions in Equations (1) to 3)) with the following linear regression

$$E_i = \alpha + \beta' X_i + \gamma' Z_i + \mu_i + \varepsilon_i \qquad (4)$$

where E_i includes two sets of outcome variables for individual *i,* for *i= 1,…, N*. The first set of outcome variables consists of the (self-reported) changes to one's income and savings due to COVID-19. There are three such variables indicating household income losses, the expected losses with one's own labor income, and changes to one's savings (compared to January 2020). To address missing value issues and obtain a better model fit, we add one to these variables before converting them to natural logarithmic form. We further change these variables to negative values (i.e., multiply them with -1) such that income losses are represented by a negative sign for easier interpretation. The variable changes to one's savings has five values ranging from 1 to 5, which respectively correspond to "*a drop of more than 10%*", "*a drop of less than 10%*", "*no change*", "*an increase of less than 10%*", and "*an increase of more than 10%*".

The second set of outcome variables consists of two subsets of variables. The first subset includes four variables indicating the immediate prevention measures against COVID-19, which include the following actions "*keep a 4-foot distance*", "*not touch one's face*", "*cover one's mouth with a tissue when sneezing*", and "*seek medical care when developing COVID-19-related symptoms*". These variables have values ranging from 1 to 5, which respectively correspond to "*never*", "*rarely*", "*sometimes*", "*very often*", and "*always*".

The second subset includes a variable indicating whether individuals changes their behavior in response to COVID-19. The survey also collects data on specific individual behavior variables before and after the outbreak, which also have the same 5 values as the first subset of outcomes with a higher value indicating a stronger level of frequency. Consequently, we create seven additional variables by subtracting the pre-outbreak behavior variables from the post-outbreak behavior variables. These variables indicate the changes to such specific activities as "*wash one's hands*", "*wear a mask*", "*eat at least 5 portions of fruit and vegetables every day*", "*take vitamin*", "*do exercises*", "*video chat with one's relatives and friends*", and "*use public transportation*" and have values ranging from -4 to 4.[7]

Our main explanatory variables (X_i) consist of the different income quintiles, where the richest quintile serves as the reference group. The vector of coefficients of interest is β, which measure the impacts of the pandemic on the different income quintiles.

The other control variables (Z_i) include age, gender, and residence areas (i.e., urban, sub-urban, or rural residence). We also include the country dummy variables to control for the country fixed effects (μ_i), with the United States serving as the reference country. For easier interpretation, we use the OLS method to estimation Equation (1), but we also offer alternative modelling options such as the Tobit and ordered probit methods for robustness checks.[8] We offer heteroskedasticity-robust variance estimates of the error term (ε_i).

III. Data Description

We analyze novel data from a recent international survey on COVID-19 conducted by Belot *et al*. (2020). This survey comprises of 6,082 respondents from six countries in different regions and at different income levels: China, Italy, Japan, South Korea, the United Kingdom, and the United States. The sample size of each country is around 1,000, ranging from 963 for South Korea

[7] For robustness check, we also offer an alternative but simpler measure of behavior changes. We return to more discussion in the next section.
[8] See, e.g., Wooldridge (2010) for a textbook treatment of these discrete choice models.

to 1,055 for the United States. In each country, the samples are nationally representative for age groups, gender, and household income quintiles. The survey did not collect data on respondents' specific incomes, but collected data on which of the five pre-COVID-19 income brackets (quintiles) they belong to.[9] Data were collected between April 15 and April 23, 2020, offering one of the most relevant multi-country datasets on socioeconomics and behavioral changes in the COVID-19 pandemic. The median time to complete the questionnaire is around 14 minutes.

We focus on certain variables from this survey for our study and provide the descriptive statistics for these variables in Table B.1 in the Appendix. We divide the variables into two groups of continuous variables and binary variables, respectively shown in Panel A and Panel B of Table B.1, for better interpretation. Table B.1 suggests that individuals on average suffer lost household income and expect to lose income as well as have somewhat less savings because of the pandemic (Panel A, rows 1 to 3). But the majority (86 percent) of individuals change their behavior because of the pandemic (Panel B, row 6). In particular, they implement prevention measures such as keeping a 4-foot distance, not touching one's face, covering one's mouth when sneezing, and seeking medical care more often (with the mean values for these activities being larger than 3; Panel A, rows 4 to 7). They also do more health activities such as washing their hands, wearing a mask, eating fruit, taking vitamin, doing exercises, video-chatting with one's relatives and friends (with the mean values for these activities being positive; Panel A, rows 8 to 13), and using the public transportation less (with the mean values for this activity being negative; Panel A, row 14).

[9] These income brackets are obtained by calculating quintiles of the gross household income distribution from the last available wave of nationally representative household surveys or census data, which capture the income distributions before the COVID-19 pandemic (Belot et al. 2020). Further comparisons of the distributions of respondents by gender and age groups in the survey and the distributions of these characteristics obtained from the official figures suggest that the differences are not large and the proportions of respondents in each income quintile in the six countries are roughly close to 20%. (Dang and Nguyen, 2021).

Individuals mostly live in urban areas (48 percent) or sub-urban areas (37 percent), with just 13 percent living in rural areas (Panel B, rows 15 to 17). About half (48 percent) of the individuals in our sample are female (Panel B, row 18).

IV. Empirical Estimates

IV.1. Impacts on Incomes and Savings

Table 1 provides estimation results on the impacts of the COVID-19 pandemic on the first set of outcome variables, which include household income losses, the expected losses with one's own labor income, and changes to one's savings. While our preferred model for interpretation includes the country fixed effects, we show estimates both without the country fixed effects (Models 1 to 3) and with the country fixed effects (Models 4 to 6) for robustness and comparison. It is reassuring to see that the estimation results are qualitatively similar whether we control for the country dummy variables or not. For subsequent analysis in Tables 2 and 3, we only show estimates that control for the country fixed effects.

Table 1 shows that the outbreak has no statistically significant impacts on household income losses for the different income quintiles (Model 4), but it has statistically significant and negative impacts on some poorer quintiles. In particular, the outbreak results in a 63-percent reduction in the expected own labor income for the second-poorest income quintile compared to the richest quintile (Model 5). The impacts of the pandemic are most noticeable in terms of savings: all the four income quintiles have more reduced savings than the richest quintiles. The savings reduction ranges from 0.13 (the poorest quintile) to 0.18 (the second-poorest quintile) on a 1-to-5 scale. These figures approximately correspond to a 5 to 7-percent decrease compared to the mean value for savings of 2.49 (Appendix 1, Table B.1). These results are consistent with the theoretical result discussed earlier (Section II.1, Propositions 2 and 3).[10] These estimation results on (expected) income loss are also qualitatively similar to the finding in Papageorge *et al.* (2020) and Belot *et al.* (2020b) that individuals in the richest income quintile are less likely to suffer income loss compared to those in the poorest income quintile.

We further show in Appendix 1, Table B.2 the t-tests that compare the differential impacts of the pandemic on the various income quintiles. The estimation results indicate that, compared to the other richer income quintiles, the larger negative impacts for the poorest income quintile are marginally statistically different for income loss, but are strongly statistically significantly for the expected loss in one's own labor income.

For the other control variables, Table 1 also suggests that compared to the age group 18-25, the older age groups (56 years old or older) expect their income to fall down less, perhaps because of better experience with managing their finance. The age groups 26-65, however, save less. Women expect their own labor income to fall more than men, but they save more than men do. The negative impacts on women are consistent with recent empirical evidence indicating that women might be more affected than men in the United Kingdom and United States (Alon *et al.*, 2020; Hupkau and Petrongolo, 2020). But while these existing studies focus on one specific country, our estimates offer more general results in a multi-country setting.[11]

IV.2. Impacts on Behavior Changes

Our theory suggests that the poor are less likely to change their behaviors to protect themselves against COVID-19 given the same risk of infection (Section II.1, Propositions 1 and 4). Indeed,

[10] The survey also collects data on the employment industries for those in the survey that work, but the sample size for these individuals is around two-thirds of the whole sample. Nevertheless, we re-run the estimates in Table 1 controlling for industry fixed effects. The estimation results, shown in Appendix 1, Table B.3, Panel A are qualitatively similar.

[11] We return to discuss the country heterogeneity impacts in Section IV.3.

Table 2 shows the empirical results that support this finding.[12] All the three poorer income quintiles implement the immediate prevention measures against COVID-19 less often than the richest quintile, and Table B.2 further indicates that the differences are generally strongly statistically significant. Only the second-richest income quintile's actions are not statistically significant from those of the richest quintile. Furthermore, it is generally the case that the poorer the individuals are, the less likely they implement these prevention measures.

In particular, individuals in the poorest quintile are 0.29 less likely to keep a 4-foot distance from another person, while the corresponding figures for the second-poorest and middle-income quintiles are lower at 0.23 and 0.15 respectively (on a 1-to-5 scale). Qualitatively similar results hold for the other prevention measures such as not touching one's face and covering one's mouth with a tissue when sneezing, with a reduction in frequency of around -0.26 for the poorest income quintile, -0.17 to -0.19 for the second-poorest and middle-income quintiles, and -0.08 to -0.14 for the second-richest income quintile. The exception is with seeking medical care when developing COVID-19-related symptoms, where the middle-income quintile shows slightly less action than the second-poorest income quintile. But this difference is not statistically significant (t-test shown in Appendix 1, Table B.2).

Table 3 provides the estimation results on the impacts of the COVID-19 pandemic on changes with healthy behaviors, which further support the results shown in Table 2. Several main results stand out for this table. First, in general, individuals in the poorer income quintiles are less likely to change their behavior to better adjust to the pandemic. More specifically, those in the poorer income quintiles are less likely to adopt new COVID-19-induced practices such as washing their hands, wearing a mask, or taking a video chat with their relatives and friends. They are also less

[12] We leave out the control variables to save space in Tables 2 and 3. We show the full regression results in Appendix 1, Tables B.4 and B.5.

likely to eat sufficient fruit and vegetables. Second, the poorer the individuals are, the less frequently they change their general behaviors for the better. Poorer individuals are also less likely to wash their hands or wear a mask compared to richer individuals.

Finally, Table 3 also shows that individuals in poorer income quintiles use public transportation more often than those in the richest quintile (Model 8). In particular, those in the three poorer income quintiles are 0.19 to 0.23 more likely to use public transportation than those in the richest quintile (on a 1-to-5 scale). This increase in frequency is more than twice higher than the corresponding difference of 0.9 between the second-richest income quintile and the richest quintile (but also note that the difference between the second-richest income quintile and the richest quintile is only marginally statistically significant at the 10 percent level). This empirical result is consistent with our theoretical result that the rich are more likely than the poor to change their behaviors given a higher risk of infection when using public transportation (as shown by $\frac{\partial M}{\partial P} \geq 0$ for $P \geq \frac{\omega}{2x}$ in the proof for Proposition 4 in Appendix 1, Part B).

We provide several different robustness checks for the results in Table 2 and Table 3. First, we re-run the estimates in these two tables and control for the industry fixed effects (for those that work). The estimation results, shown in Appendix 1, Table B.3, Panel B are qualitatively similar. Second, instead of employing the OLS method, we use the Tobit and ordered probit models to re-estimate the impacts of the pandemic on behavior changes. But the estimation results, shown in Appendix 1, Tables B.6 and B.7, are qualitatively similar. Finally, we also offer an alternative but simpler measure of behavior changes that indicate whether the post-outbreak behaviors have less frequency, the same frequency, or more frequency compared to the pre-outbreak behaviors. Put differently, these alternative behavior change variables have three values only. The estimation results, shown in Appendix 1, Table B.8, are also qualitatively similar. Furthermore, the t-tests that compare the estimated impacts on the various income quintiles, shown in Appendix 1, Table B.2, confirm that the more negative impacts that the poorest income quintile suffers compared to the richer income quintiles are strongly statistically significant.

IV.3. Country Heterogeneity

We plot in Figure 1 the heterogeneous impacts of COVID-19 on countries that are shown in Tables 1 to 3. Figure 1 shows that the impacts of the pandemic vary from country to country, and countries exhibit heterogeneity for all the two sets of outcome variables. Furthermore, several specific remarks are in order. First, for the first set of outcome variables, compared with all the 6 countries, the United Kingdom consistently comes out as the country with the least household income loss and expected labor income loss, and the most savings. Interestingly, the opposite of the United Kingdom is South Korea, which has the most household income loss and expected labor income loss. The remaining countries display more complex patterns; for example, compared to the United States, China has more income loss but less expected labor income loss and less savings.

Second, Japan is the country that is least likely to adopt behavioral changes. This country scores the least in terms of a number of activities ranging from keeping a 4-foot distance and not touching one’s face to eating sufficient fruit and vegetables and video chatting. Italy, however, is the opposite and most likely to have behavioral changes. Finally, some countries stand out in certain activities. For example, Chinese, Italians, and South Koreans tend to wash their hands and wear a mask more often than the remaining countries.

V. Further Discussion and Conclusion

We contribute new evidence on the distributional impacts of the COVID-19 pandemic on the different income groups using rich micro survey data from six countries in different geographical locations and at different income levels. We offer a new theoretical model that is built on the economics and epidemiology literatures to guide our empirical analysis.

We find that while the outbreak has no statistically significant impacts on household income losses for the different income quintiles, it results in a 63-percent reduction in the expected own labor income for the second-poorest income quintile compared to the richest quintile. The impacts of the pandemic are most noticeable in terms of savings, with all the four poorer income quintiles have reduced savings ranging between 5 and 7 percent compared to the mean. We also find that the poor are less likely to change their behaviors to protect themselves against COVID-19, both in terms of immediate prevent measures such as keeping a 4-foot physical distance and healthy activities such as washing one's hands or wearing a mask. The poorer individuals are, the less likely they are to adopt healthy behavior changes.

Our findings suggest that even if the pandemic may not have immediate impacts on the poor, it may decrease their incomes and health in the future. Furthermore, economic and epidemiological conditions may combine and result in poverty traps that determine the long-term trajectory of the health and economic development of a society (Bond *et al.*, 2010; Barret and Carter, 2013; Kraay and McKenzie, 2014). As such, designing tailor-made social protection and health policies to support the poorer income groups, in both richer and poorer countries, can generate multiple positive impacts that help minimize the negative and inequality-enhancing consequences of the COVID-19 pandemic.

Our findings also suggest that countries exhibit heterogeneous impacts and behavior changes due to the pandemic. While the United Kingdom has the least household income loss and expected labor income loss, and the most savings, South Korea has the most household income loss and expected labor income loss. Japan is the country that is least likely to adapt behavioral changes, but Chinese, Italians, and South Koreans tend to wash their hands and wear a mask more often than the remaining countries.

This latter result indicates that cultural factors may take an important role in common hygiene practices and are consistent with recent findings in the public health literature (e.g., West *et al.* (2020)). In particular, Feng *et al.* (2020) observe that wearing a face mask is considered hygienic practice in many Asian countries but something only people who are unwell do in European and North American countries. Applying the precautionary principle, Greenhalgh *et al*. (2020) also encourage the use of face masks on the grounds that we have little to lose and potentially something to gain from this measure. Most recently, Mitze *et al.* (2020) find face masks to reduce the daily growth rate of reported infections by around 40% in Germany. As such, public education campaigns may be useful to reduce the stigma and discrimination that is associated with wearing a mask in certain countries. Our findings thus add to this policy discussion on public health measures against the pandemic.

These concerns have practical relevance not only for Covid-19 but also future pandemic. Government responses to the pandemic have varied widely across countries and have been successful to varying degrees, at least during the initial reactions (Cheng *et al.*, 2020; Hale *et al.*, 2021). These responses require strong support from all population groups to be effective. But some evidence suggests that poorer individuals are less supportive of government responses and poorer individuals residing in more economically unequal countries offer even less government support during the pandemic (Dang *et al.*, 2022). These findings are consistent with earlier findings for the U.S. that poorer individuals face financial resources constraints during the pandemic that limit their behavior changes or mobility patterns (Weill *et al.*, 2020; Kim and Kwan, 2021).

Consequently, governments may be able to gather more support from the poorer population groups by offering special social protection programs that target these groups during a crisis.

We also put a caveat on our main findings. This study looks at the inequality among groups across countries at the first wave, when the vaccination campaign has not started yet. This study reflects the existing inequality whereas we leave the open door for the future study to evaluate the inequality within and between countries in the next stage of having vaccine. While the execution of vacation also generates some possible inequality, our policy recommendation would emphasize the role of government to immediately take an action to support the minority group when the pandemic could have happened in the future.

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Table 1. Inequality in lost income, expected loss in own labor income, and savings

Variables	(Model 1) Log(LI)	(Model 2) Log (ELI)	(Model 3) Change savings	(Model 4) Log(LI)	(Model 5) Log (ELI)	(Model 6) Change savings
Poorest quintile	0.028	0.141	-0.146***	0.170	0.211	-0.128***
	(-0.204)	(-0.208)	(-0.044)	(-0.201)	(-0.204)	(-0.044)
Second-poorest quintile	-0.223	-0.648***	-0.189***	-0.150	-0.628***	-0.175***
	(-0.205)	(-0.213)	(-0.043)	(-0.202)	(-0.209)	(-0.043)
Middle-income quintile	-0.218	-0.261	-0.160***	-0.161	-0.224	-0.143***
	(-0.198)	(-0.205)	(-0.042)	(-0.196)	(-0.203)	(-0.042)
Second-richest quintile	-0.186	-0.305	-0.042	-0.182	-0.326	-0.03
	(-0.2)	(-0.204)	(-0.042)	(-0.197)	(-0.202)	(-0.042)
Age group (26 to 35)	0.224	-0.09	-0.104*	0.123	-0.102	-0.117**
	(-0.237)	(-0.244)	(-0.055)	(-0.235)	(-0.244)	(-0.055)
Age group (36 to 45)	0.141	-0.165	-0.202***	0.08	-0.191	-0.208***
	(-0.235)	(-0.241)	(-0.054)	(-0.231)	(-0.24)	(-0.053)
Age group (46 to 55)	0.286	-0.141	-0.217***	0.245	-0.077	-0.227***
	(-0.238)	(-0.246)	(-0.053)	(-0.234)	(-0.243)	(-0.053)
Age group (56 to 65)	1.215***	0.705***	-0.091*	1.052***	0.677***	-0.114**
	(-0.244)	(-0.251)	(-0.055)	(-0.239)	(-0.249)	(-0.055)
Age group (66 to 75)	2.442***	2.448***	0.126**	2.289***	2.464***	0.110*
	(-0.246)	(-0.245)	(-0.058)	(-0.241)	(-0.241)	(-0.058)
Age group (Above 76)	2.623***	2.992***	0.078	2.511***	2.929***	0.061
	(-0.321)	(-0.299)	(-0.072)	(-0.318)	(-0.302)	(-0.072)
Age group (Prefer not to say)	-0.347	1.321	-0.642	-0.404	1.997	-0.646
	(-2.134)	(-1.586)	(-0.595)	(-2.363)	(-1.917)	(-0.55)
Female	0.035	-0.454***	0.060**	0.043	-0.426***	0.061**
	(-0.126)	(-0.13)	(-0.027)	(-0.125)	(-0.128)	(-0.027)
Urban	-0.800***	-0.254	-0.112***	-0.381**	-0.364*	-0.047
	(-0.19)	(-0.198)	(-0.041)	(-0.192)	(-0.2)	(-0.043)
Sub-urban	-0.114	0.156	0.032	-0.032	0.043	0.03
	(-0.192)	(-0.199)	(-0.042)	(-0.192)	(-0.199)	(-0.043)
China				-1.187***	0.268	-0.195***
				(-0.197)	(-0.194)	(-0.05)
Italy				0.196	-0.298*	-0.124**
				(-0.172)	(-0.176)	(-0.052)
Japan				-0.202	-1.574***	0.062
				(-0.219)	(-0.222)	(-0.044)
Korea				-1.799***	-2.197***	-0.067
				(-0.258)	(-0.263)	(-0.047)
United Kingdom				0.933***	0.633***	0.141***
				(-0.173)	(-0.171)	(-0.046)
Constant	-4.507***	-3.959***	2.704***	-4.389***	-3.384***	2.702***
	(-0.281)	(-0.286)	(-0.064)	(-0.303)	(-0.308)	(-0.071)
RMSE	4.878	5.02	1.054	4.801	4.92	1.049
Adjusted R^2	0.038	0.042	0.019	0.068	0.08	0.028
N	6089	6088	6089	6089	6088	6089

Notes: * < 0.1, ** < 0.05, *** < 0.01. Robust standard errors are in brackets. LI and ELI stand for "lost income" and "expected loss in labor income". The reference groups are the richest quintile for income quintiles, age group 18-25 for age groups, rural residence for residence areas, and the United States for countries.

Table 2. Inequality with changes in prevention measures against COVID-19

Variables	(Model 1) Keep 4 ft. distance	(Model 2) Not touch face	(Model 3) Cover mouth when sneezing	(Model 4) Seek medical care
Poorest quintile	-0.287***	-0.265***	-0.263***	-0.260***
	(0.051)	(0.050)	(0.049)	(0.068)
Second-poorest quintile	-0.231***	-0.191***	-0.173***	-0.141**
	(0.048)	(0.047)	(0.047)	(0.066)
Middle-income quintile	-0.154***	-0.137***	-0.077*	-0.206***
	(0.045)	(0.044)	(0.043)	(0.063)
Second-richest quintile	-0.037	-0.060	-0.005	0.018
	(0.043)	(0.043)	(0.041)	(0.063)
RMSE	1.157	1.146	1.132	1.616
Adjusted R^2	0.162	0.069	0.061	0.114
N	6089	6089	6089	6089

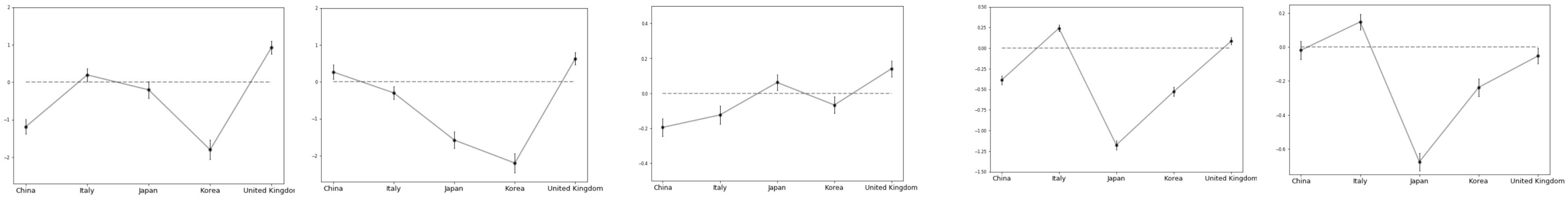
Notes: * < 0.1, ** < 0.05, *** < 0.01. Robust standard errors are in brackets. The reference group is the richest quintile. All regression models include the same control variables as with Table 1, which are age groups, gender, residence areas, and country fixed effects. The full regression results are shown in Appendix 1, Table B.4.

Table 3. Inequality with changes in daily behavior

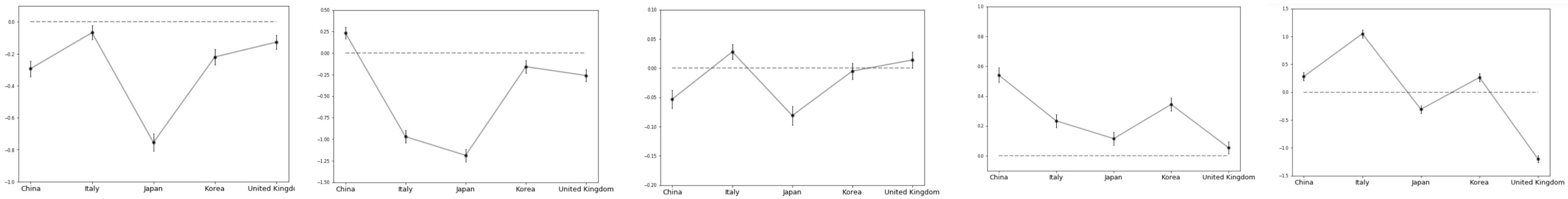
Variables	(Model 1) Change behavior	(Model 2) Wash hand	(Model 3) Wear mask	(Model 4) Eat fruit	(Model 5) Take vitamin	(Model 6) Do exercises	(Model 7) Video chat	(Model 8) Public trans.
Poorest quintile	-0.107***	-0.188***	-0.473***	-0.068**	-0.041	0.011	-0.147***	0.187***
	(0.015)	(0.042)	(0.064)	(0.031)	(0.029)	(0.041)	(0.050)	(0.049)
Second-poorest quintile	-0.055***	-0.089**	-0.186***	-0.026	-0.031	0.026	-0.096*	0.226***
	(0.014)	(0.042)	(0.063)	(0.032)	(0.030)	(0.041)	(0.051)	(0.049)
Middle-income quintile	-0.035***	-0.083**	-0.217***	-0.047	-0.113***	-0.001	-0.073	0.229***
	(0.013)	(0.041)	(0.061)	(0.031)	(0.027)	(0.040)	(0.050)	(0.047)
Second-richest quintile	0.006	-0.020	-0.085	-0.012	0.006	-0.013	0.046	0.088*
	(0.012)	(0.040)	(0.059)	(0.031)	(0.028)	(0.040)	(0.050)	(0.048)
RMSE	0.337	1.007	1.542	0.752	0.699	0.985	1.221	1.155
Adjusted R^2	0.044	0.039	0.171	0.070	0.039	0.040	0.017	0.047
N	6089	6089	6089	6089	6089	6089	6089	6089

Notes: * < 0.1, ** < 0.05, *** < 0.01. Robust standard errors are in brackets. “Public trans.” stands for "taking public transportation". The reference group is the richest quintile. All regression models include the same control variables as with Table 1, which are age groups, gender, residence areas, and country fixed effects. The full regression results are shown in Appendix 1, Table B.5.

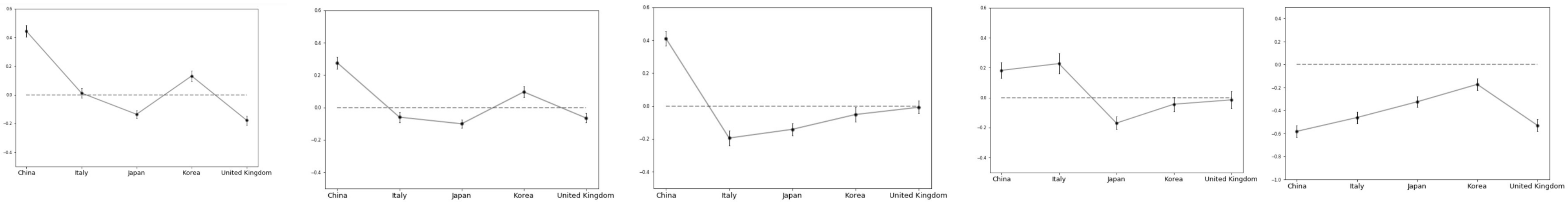
Figure 1. Heterogeneity of country impact



(i) Income loss (ii) Expected loss in own labor income (iii) Changed savings (iv) Keep 4 ft. distance (v) Not touch face



(vi) Cover mouth when sneezing (vii) Seek medical care (viii) change behavior (ix) Wash hand (x) Wear mask



(xi) Eat fruit (xii) Take vitamin (xiii) Do exercises (xiv) Video call (xv) Using public transportation

Notes: These graphs show the estimated coefficients obtained from the regression results in Tables 1 to 3. The reference country is the United States.

Appendix 1. Supplementary Materials

Part A. Theoretical Proofs

The disease dynamics between period t and period $t+1$ follow the standard SIR model:

$$S_{t+1} = S_t - \alpha S_t I_t / N_t$$
$$I_{t+1} = I_t + \alpha S_t I_t / N_t - \Psi I_t$$
$$R_{t+1} = R_t + \Psi I_t$$
$$S_0, I_0, N_0 > 0 \text{ with } N_0 = S_0 + I_0.$$

where S_t is the number of susceptible, I_t is the number of infectious, and R_t is the number of recovered or deceased individuals in period t. The epidemiology parameters are the contact rate α, (i.e., the average number of contacts of a person to catch the disease per time unit) and Ψ (i.e., the recovery rate from the disease). Assuming the proportion of the households in each disease status is identical to the corresponding figure in the general population. Thus in the household, $s_t = \frac{S_t}{N}$ is the fraction of healthy individuals, $i_t = \frac{I_t}{N}$ is the fraction of infected individuals, and $r_t = \frac{R_t}{N}$ is the fraction of that that is recovered from the disease and no longer infectious where $1 = s_t + i_t + r_t$.

Proposition 1. *The price of healthcare service decreases the demand for healthcare and labor supply.*

Proof

At the optimal we have

$$U'(y + \omega L_0 - PM - S) = xV'(xS + \omega(L_0(1-\alpha) + L_0^2\,\alpha + (1 - L_0)\Psi(M))) \quad (1.1)$$

$$\omega(1 - L_0)\Psi_M(M) - xP = 0 \quad (1.2)$$

$$\Psi(M) = 2L_0\alpha + x + 1 - \alpha \quad (1.3)$$

It follows from (1.3) that

$$L_0 = \frac{\Psi(M) + \alpha - x - 1}{2\alpha}.$$

The equation (1.2) becomes

$$\omega\big(\alpha + x + 1 - \Psi(M)\big)\Psi'(M) = 2\alpha x P. \quad (1.4)$$

Totally differentiating equation (1.4) with respect to M and P yields

$$\frac{\partial M}{\partial P} = \frac{2\alpha x P}{\omega(\alpha + x + 1 - \Psi)\Psi'' - \omega\Psi'^2}. \quad (1.5)$$

$$\frac{\partial L_0}{\partial P} = \frac{\Psi'}{2\alpha}\frac{\partial M}{\partial P} = \frac{x\Psi'}{\omega(\alpha + x + 1 - \Psi)\Psi'' - \omega\Psi'^2}. \quad (1.6)$$

By (1.3), we have

$$\alpha + x + 1 - \Psi = 2\alpha(1 - L_0) > 0. \quad (1.7)$$

Therefore, we have $\omega(\alpha + x + 1 - \Psi)\Psi'' - \omega\Psi'^2 < 0$ because $\Psi'' < 0$.
We also have $\frac{\partial M}{\partial P} < 0$ and $\frac{\partial L_0}{\partial P} < 0$.

Proposition 2. *The poor's labor income are likely unaffected by the pandemic in the current period, but may be more affected in the next period.*

Proof
By (1.6) we get

$$\frac{\partial D_0}{\partial P} = -\frac{\omega \partial L_0}{\partial P} = \frac{x\Psi'}{\Psi'^2 - \omega(\alpha + x + 1 - \Psi)\Psi''} > 0.$$

The poorest are likely unaffected in terms of the labor income loss, which is confirmed by the empirical results.
We have

$$\frac{\partial D_1}{\partial P} = -\frac{\partial Y_1}{\partial P} = -\omega\frac{\partial L_1}{\partial P}.$$

By (1.7) we have $1 - \Psi = 2\alpha(1 - L_0) - \alpha - x$. Hence,

$$\begin{aligned}\frac{\partial L_1}{\partial P} &= (1 - \Psi - \alpha + 2\alpha L_0)\frac{\partial L_0}{\partial P} - L_0\Psi'\frac{\partial M}{\partial P} \\ &= -(\frac{x + 2\alpha L_0}{2\alpha})\frac{\Psi'\partial M}{\partial P} \\ &= \frac{-x(x + 2\alpha L_0)\Psi'}{\omega(\alpha + x + 1 - \Psi)\Psi'' - \omega\Psi'^2} > 0.\end{aligned} \tag{1.8}$$

$$\frac{\partial D_1}{\partial P} = -\omega\frac{\partial L_1}{\partial P} < 0.$$

By assumption, there is a monotone and increasing relationship between the price of healthcare and income which implies

$$\frac{\partial D_1}{\partial y} < 0.$$

When y decreases below a poverty threshold , the expected loss D_1 increases for the poor. The poor may expect income loss in the next period.

Proposition 3. *The poor have less savings than the rich in the pandemic.*

Proof
Let us denote $\frac{\partial M}{\partial P} = X$ where

$$X = \frac{2\alpha x}{\omega(\alpha + x + 1 - \Psi)\Psi'' - \omega\Psi'^2} < 0$$

and

$$\frac{\partial Y_1}{\partial P} = -\omega\frac{\partial L_1}{\partial P} = Z.$$

where

$$Z = \frac{-x(x + 2\alpha L_0)\Psi'}{\omega(\alpha + x + 1 - \Psi)\Psi'' - \omega\Psi'^2} > 0.$$

Totally differentiating equation (1.1) with respect to M, S, L_0 and P we have

$$\left(\omega\frac{\partial L_0}{\partial P} - M - P\frac{\partial M}{\partial P} - \frac{\partial S}{\partial P}\right)U'' - x\left(x\frac{\partial S}{\partial P} + \frac{\partial Y_1}{\partial P}\right)V''$$
$$= -\frac{\partial S}{\partial P}(U'' + x^2V'') + U''\left(\frac{\omega\Psi'}{2\alpha}\frac{\partial M}{\partial P} - M\right) - x\frac{\partial Y_1}{\partial P}V'' - P\frac{\partial M}{\partial P}U''$$
$$= -\frac{\partial S}{\partial P}(U'' + x^2V'') + \left(\frac{\omega X\Psi'}{2\alpha} - M\right)U'' - xZV'') - PXU'' = 0.$$

Therefore,

$$\frac{\partial S}{\partial P} = \frac{\left(\frac{-\omega\Psi'}{2\alpha} + M\right)U'' + xZV'' + PXU''}{-U'' - x^2V''}.$$

which can be rewritten as $(-U'' - x^2V'')\frac{\partial S}{\partial P}(P) = \alpha_1(P)P + \alpha_0(P)$. Because X < 0, Z > 0, $U'' < 0, V'' < 0$, we have, for any P,

$$\alpha_1(P) = XU'' > 0$$
$$\alpha_0(P) = \left(\frac{-\omega\Psi'}{2\alpha}X + M\right)U'' + xZV'' < 0.$$

Note that $sign\left\{\frac{\partial S}{\partial P}(P)\right\} = sign\{H(P)\}$ where $H(P) = a_1(P)P + a_0(P)$. Because $H(0) = a_0(0) < 0$ and H(P) is continuous, H(P) < 0 in the neighborhood of zero. It means $\frac{\partial S}{\partial P}(P) < 0$ for P that is small enough. This implies

$$\frac{\partial S}{\partial y} < 0.$$

Thus the poor are less likely to have savings.

Proposition 4. *Given the same risk of infection, the rich are more likely to change their behavior than the poor.*

Proof

We have shown that $\frac{\partial M}{\partial P} < 0$, which implies that the poor likely have reduced investments in healthcare compared to the rich.

From the budget constraint at period zero, it follows that

$$\frac{\partial C_0}{\partial P} = \omega\frac{\partial P_0}{\partial P} - P\frac{\partial M}{\partial P} - M - \frac{\partial S}{\partial P}$$
$$= \left(\frac{\omega\Psi'}{2\alpha} - P\right)\frac{\partial M}{\partial P} - M - \frac{\partial S}{\partial P}.$$

For the poor with small P, we have $\frac{\partial C_0}{\partial P} + \frac{\partial S}{\partial P} = \left(\frac{\omega\Psi'}{2\alpha} - P\right)\frac{\partial M}{\partial P} - M < 0$. So either their consumption or their savings decrease.

Moreover, from (1.4) we have

$$\frac{\partial M}{\partial \alpha} = \frac{2xP - \omega}{\omega(\alpha + x + 1 - \Psi)\Psi'' - \omega\Psi'^2}.$$

If $P < \frac{\omega}{2x}$ then $\frac{\partial M}{\partial P} < 0$ and $\frac{\partial M}{\partial P} \geq 0$ for $P \geq \frac{\omega}{2x}$. Consequently, the poor do not invest more in healthcare despite the risk of infection (as measured by the contact rate α). On the other hand, the rich are more likely to change their behavior given the same risk of infection.

Part B. Additional Tables

Table B.1. Summary statistics

Panel A: Continuous variables

Variable	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis
Log(Lost income)	-4.31	4.97	-20.21	0.00	-0.62	1.99
Log (ELI)	-3.97	5.13	-22.33	0.00	-0.83	2.28
Change savings	2.49	1.06	1.00	5.00	0.11	2.59
Keep 4 ft. distance	4.15	1.26	1.00	5.00	-1.40	3.75
Not touch face	3.76	1.19	1.00	5.00	-0.79	2.79
Cover mouth when sneezing	4.19	1.17	1.00	5.00	-1.50	4.32
Seek medical care	3.25	1.72	1.00	5.00	-0.28	1.35
Change with washing hand	0.78	1.03	-4.00	4.00	0.48	3.88
Change with wearing a mask	1.70	1.69	-4.00	4.00	0.08	1.62
Change with eating fruit	0.28	0.78	-4.00	4.00	1.28	8.15
Change with taking vitamin	0.17	0.71	-4.00	4.00	1.47	11.37
Change with doing exercises	0.01	1.01	-4.00	4.00	-0.17	6.65
Change with video chat	0.31	1.23	-4.00	4.00	-0.11	5.30
Change with using public trans.	-0.79	1.18	-4.00	4.00	-0.83	3.72

Panel B: Binary variables

Variable	Mean	Std. Dev.	% of 0	% of 1	Skewness	Kurtosis
Poorest quintile	0.18	0.39	81.33	18.67	1.61	3.58
Second-poorest quintile	0.18	0.38	81.51	18.49	1.62	3.63
Middle-income quintile	0.20	0.40	79.16	20.84	1.436	3.06
Second-richest quintile	0.21	0.41	78.40	21.60	1.38	2.90
Richest quintile	0.18	0.38	81.89	18.11	1.65	3.74
Changed behaviors	0.86	0.34	13.73	86.27	-2.10	5.44
Age group (18 to 25)	0.12	0.32	87.91	12.09	2.32	6.41
Age group (26 to 35)	0.17	0.38	82.31	17.69	1.69	3.86
Age group (36 to 45)	0.19	0.39	81.01	18.99	1.58	3.50
Age group (46 to 55)	0.18	0.38	81.41	18.59	1.61	3.60
Age group (56 to 65)	0.15	0.36	84.43	15.57	1.89	4.60
Age group (66 to 75)	0.12	0.33	87.42	12.58	2.25	6.09
Age group (Above 76)	0.04	0.20	95.58	4.42	4.43	20.68
Age group (Prefer not to say)	0.00	0.02	99.92	0.08	34.85	1215.80
Urban	0.48	0.50	51.17	48.83	0.04	1.00
Sub-urban	0.37	0.48	62.33	37.67	0.50	1.25
Rural	0.13	0.34	86.50	13.50	2.13	5.56
Female	0.48	0.50	51.60	48.40	0.06	1.00
China	0.16	0.37	83.64	16.36	1.81	4.30
Italy	0.17	0.37	82.85	17.15	1.74	4.03
Japan	0.16	0.37	83.33	16.67	1.78	4.19
Korea	0.15	0.36	84.18	15.82	1.87	4.51
United Kingdom	0.16	0.37	83.31	16.69	1.78	4.19
United States	0.17	0.37	82.67	17.33	1.72	3.98

Notes: The number of observations is 6,089 for all the variables.

Table B.2. T-test for the different quintiles in income inequality and changes in daily behaviors

Dependent variables	qt1 = qt2	qt1 = qt3	qt1 = qt4	qt2 = qt3	qt2 = qt4	qt3 = qt4
Log (Lost income)	2.62	2.95*	3.23*	0.01	0.03	0.01
Log (ELI)	17.47***	4.90**	7.53***	4.03**	2.25	0.28
Changed savings	1.15	0.13	5.11**	0.54	11.61***	7.44***
Keep 4 ft. distance	1.15	7.02***	26.88***	2.54	17.76***	7.62***
Not touch face	2.03	6.72***	17.78***	1.32	8.05***	3.22*
Cover mouth when sneezing	2.97*	14.14***	28.91***	4.17**	13.64***	3.00*
Seek medical care	2.85*	0.62	16.69***	0.96	5.78**	12.45***
Change behavior	10.66***	22.17***	60.83***	1.85	20.39***	11.21***
Wash hand	5.52**	6.58**	16.80***	0.02	2.78*	2.57
Wear mask	18.63***	15.55***	37.49***	0.23	2.62	4.77**
Eat fruit	1.83	0.46	3.50*	0.49	0.20	1.46
Take vitamin	0.11	6.68***	2.73*	8.28***	1.65	20.13
Do exercises	0.14	0.08	0.36	0.44	0.96	0.10
Video chat	1.09	2.29	15.45***	0.21	7.81***	5.65**
Public transportation	0.63	0.78	4.43**	0.01	8.64***	9.99***

Notes: * < 0.1, ** < 0.05, *** < 0.01. This table presents the t-tests for the estimated coefficients on the income quintiles in Tables 1 to 3. LI and ELI stand for "lost income" and "expected loss in labor income". The notations "qt1", "qt2", "qt3", and "qt4 respectively stand for the poorest quintile, second-poorest quintile, middle-income quintile, and second-richest quintile. The reference group is the richest income quintile.

Table B.3. Robust regressions for main results with controlling for industry fixed effects

Panel A: Inequality in lost income, expected loss in own labor income, and savings

Variables	Log(LI)	Log (ELI)	Change savings
Poorest quintile	-0.388	-0.228	-0.076
	(-0.284)	(-0.289)	(-0.065)
Second-poorest quintile	-0.163	-0.741***	-0.192***
	(-0.253)	(-0.26)	(-0.054)
Middle-income quintile	0.05	-0.129	-0.134***
	(-0.233)	(-0.243)	(-0.051)
Second-richest quintile	0.056	-0.18	0.003
	(-0.228)	(-0.234)	(-0.048)
Age group (26 to 35)	0.138	0.134	-0.058
	(-0.274)	(-0.289)	(-0.068)
Age group (36 to 45)	-0.046	-0.096	-0.172***
	(-0.268)	(-0.285)	(-0.066)
Age group (46 to 55)	0.039	-0.16	-0.205***
	(-0.279)	(-0.293)	(-0.067)
Age group (56 to 65)	0.243	-0.187	-0.119*
	(-0.305)	(-0.323)	(-0.072)
Age group (66 to 75)	0.52	0.707	0.06
	(-0.428)	(-0.45)	(-0.107)
Age group (Above 76)	-0.785	-0.846	-0.133
	(-0.818)	(-0.869)	(-0.17)
Age group (Prefer not to say)	-0.3	3.01	-0.499
	(-2.611)	(-2.079)	(-0.592)
Constant	-6.657***	-6.030***	2.463***
	(-0.496)	(-0.517)	(-0.122)
Demographic characteristics	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
RMSE	4.885	5.065	1.079
Adjusted R^2	0.054	0.078	0.032
N	4103	4103	4103

Notes: * < 0.1, ** < 0.05, *** < 0.01. Robust standard errors are in brackets. LI and ELI stand for "lost income" and "expected loss in labor income". The reference groups are the richest quintile for income quintiles and age group 18-25 for age groups. The other demographic characteristics include gender and residence areas. There are 20 industries dummy variables for the industry fixed effects and the 'Accommodation and Food Services' is the reference group.

Panel B: Inequality with changes in prevention measures against COVID

Variables	Keep 4 ft. distance	Not touch face	Cover mouth when sneezing	Seek medical care
Poorest quintile	-0.231***	-0.171**	-0.212***	-0.243***
	(-0.07)	(-0.07)	(-0.069)	(-0.091)
Second-poorest quintile	-0.311***	-0.229***	-0.248***	-0.199**
	(-0.061)	(-0.058)	(-0.06)	(-0.078)
Middle-income quintile	-0.236***	-0.145***	-0.127**	-0.215***
	(-0.054)	(-0.052)	(-0.051)	(-0.073)
Second-richest quintile	-0.110**	-0.090*	-0.035	0.002
	(-0.051)	(-0.049)	(-0.048)	(-0.07)
Age group (26 to 35)	0.101	0.108	-0.032	-0.107

	(-0.07)	(-0.067)	(-0.061)	(-0.082)
Age group (36 to 45)	0.145**	0.166**	-0.062	-0.12
	(-0.07)	(-0.066)	(-0.062)	(-0.082)
Age group (46 to 55)	0.163**	0.113*	-0.065	-0.474***
	(-0.072)	(-0.069)	(-0.065)	(-0.087)
Age group (56 to 65)	0.205***	0.149**	-0.096	-0.512***
	(-0.077)	(-0.074)	(-0.072)	(-0.095)
Age group (66 to 75)	0.361***	0.306***	0.071	-0.275**
	(-0.101)	(-0.097)	(-0.093)	(-0.135)
Age group (Above 76)	-0.02	-0.132	-0.414**	-0.585**
	(-0.213)	(-0.195)	(-0.206)	(-0.256)
Age group (Prefer not to say)	0.084	0.513	-0.31	-1.091*
	(-0.712)	(-0.75)	(-0.768)	(-0.607)
Constant	4.479***	4.047***	4.770***	4.060***
	(-0.128)	(-0.122)	(-0.118)	(-0.162)
Demographic characteristics	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
RMSE	1.176	1.137	1.135	1.563
Adjusted R^2	0.146	0.071	0.052	0.128
N	4103	4103	4103	4103

Notes: * < 0.1, ** < 0.05, *** < 0.01. Robust standard errors are in brackets. The reference groups are the richest quintile for income quintiles and age group 18-25 for age groups. The other demographic characteristics include gender and residence areas. There are 20 industries dummy variables for the industry fixed effects and the 'Accommodation and Food Services' is the reference group.

Panel C: Inequality with changes in daily behavior

Variables	Change behavior	Wash hand	Wear mask	Eat fruit	Take vitamin	Do exercises	Video chat	Public trans.
Poorest quintile	-0.068***	-0.196***	-0.585***	-0.112**	-0.071	-0.013	-0.157**	0.167**
	(-0.02)	(-0.062)	(-0.092)	(-0.048)	(-0.045)	(-0.059)	(-0.07)	(-0.072)
Second-poorest quintile	-0.045***	-0.125**	-0.319***	-0.046	-0.055	0.046	-0.194***	0.274***
	(-0.016)	(-0.053)	(-0.078)	(-0.041)	(-0.039)	(-0.052)	(-0.063)	(-0.06)
Middle-income quintile	-0.044***	-0.120**	-0.389***	-0.098***	-0.134***	-0.045	-0.123**	0.308***
	(-0.014)	(-0.049)	(-0.072)	(-0.037)	(-0.034)	(-0.048)	(-0.058)	(-0.055)
Second-richest quintile	-0.006	-0.086*	-0.225***	-0.031	-0.017	-0.005	-0.043	0.096*
	(-0.013)	(-0.047)	(-0.068)	(-0.037)	(-0.034)	(-0.047)	(-0.057)	(-0.056)
Age group (26 to 35)	0.013	0.06	0.117	0.053	0.037	-0.098*	-0.078	0.091
	(-0.017)	(-0.061)	(-0.092)	(-0.048)	(-0.043)	(-0.058)	(-0.071)	(-0.076)
Age group (36 to 45)	0.004	0.015	-0.1	0.02	0.038	-0.088	-0.092	0.049
	(-0.018)	(-0.062)	(-0.092)	(-0.047)	(-0.044)	(-0.056)	(-0.07)	(-0.075)
Age group (46 to 55)	-0.031*	0.018	-0.088	0.004	0.005	-0.183***	-0.156**	0.163**
	(-0.019)	(-0.062)	(-0.093)	(-0.047)	(-0.042)	(-0.057)	(-0.069)	(-0.074)
Age group (56 to 65)	-0.050**	0.120*	0.024	0.002	-0.028	-0.191***	-0.189**	0.049
	(-0.021)	(-0.067)	(-0.1)	(-0.048)	(-0.046)	(-0.062)	(-0.075)	(-0.079)

Age group (66 to 75)	-0.043	0.179**	0.061	0.084	0.016	-0.123	-0.282***	-0.016
	(-0.031)	(-0.082)	(-0.134)	(-0.065)	(-0.059)	(-0.081)	(-0.103)	(-0.099)
Age group (Above 76)	-0.019	0.358*	-0.407	0.087	-0.126	-0.033	-0.178	0.207
	(-0.056)	(-0.187)	(-0.257)	(-0.116)	(-0.114)	(-0.133)	(-0.157)	(-0.187)
Age group (Prefer not to say)	-0.628***	0.774	0.16	0.26	-0.374	0.497**	-0.216	0.421
	(-0.202)	(-0.648)	(-0.469)	(-0.173)	(-0.284)	(-0.251)	(-0.177)	(-0.477)
Constant	0.951***	0.632***	1.911***	0.183**	0.206***	0.310***	0.612***	-0.701***
	(-0.035)	(-0.115)	(-0.172)	(-0.092)	(-0.076)	(-0.105)	(-0.13)	(-0.132)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RMSE	0.319	1.034	1.546	0.795	0.738	1.007	1.236	1.182
Adjusted R^2	0.048	0.04	0.157	0.072	0.037	0.047	0.019	0.048
N	4103	4103	4103	4103	4103	4103	4103	4103

Notes: * < 0.1, ** < 0.05, *** < 0.01. Robust standard errors are in brackets. The reference groups are the richest quintile for income quintiles and age group 18-25 for age groups. The other demographic characteristics include gender and residence areas. There are 20 industries dummy variables for the industry fixed effects and the 'Accommodation and Food Services' is the reference group.

Table B.4. Inequality with changes in prevention measures against COVID-19

Variables	(Model 1) Keep 4 ft. distance	(Model 2) Not touch face	(Model 3) Cover mouth when sneezing	(Model 4) Seek medical care
Poorest quintile	-0.287***	-0.265***	-0.263***	-0.260***
	(0.051)	(0.050)	(0.049)	(0.068)
Second-poorest quintile	-0.231***	-0.191***	-0.173***	-0.141**
	(0.048)	(0.047)	(0.047)	(0.066)
Middle-income quintile	-0.154***	-0.137***	-0.077*	-0.206***
	(0.045)	(0.044)	(0.043)	(0.063)
Second-richest quintile	-0.037	-0.060	-0.005	0.018
	(0.043)	(0.043)	(0.041)	(0.063)
Age group (26 to 35)	0.060	0.128**	0.001	-0.156**
	(0.057)	(0.056)	(0.052)	(0.071)
Age group (36 to 45)	0.095*	0.177***	-0.044	-0.147**
	(0.057)	(0.055)	(0.053)	(0.070)
Age group (46 to 55)	0.117**	0.126**	-0.043	-0.488***
	(0.058)	(0.057)	(0.054)	(0.073)
Age group (56 to 65)	0.228***	0.211***	0.015	-0.538***
	(0.059)	(0.058)	(0.056)	(0.077)
Age group (66 to 75)	0.309***	0.195***	0.020	-0.499***
	(0.060)	(0.061)	(0.059)	(0.084)
Age group (Above 76)	0.231***	0.188**	0.004	-0.511***
	(0.085)	(0.083)	(0.078)	(0.118)
Age group (Prefer not to say)	0.135	0.652	-0.086	-0.929*
	(0.591)	(0.648)	(0.624)	(0.559)
Female	-0.220***	-0.183***	-0.242***	-0.064
	(0.030)	(0.030)	(0.029)	(0.042)
Urban	0.036	0.126***	-0.044	0.077
	(0.049)	(0.049)	(0.049)	(0.069)
Sub-urban	0.027	-0.000	-0.014	0.039
	(0.049)	(0.048)	(0.048)	(0.070)
China	-0.388***	-0.019	-0.293***	0.235***
	(0.052)	(0.053)	(0.049)	(0.066)
Italy	0.242***	0.148***	-0.068	-0.970***
	(0.040)	(0.045)	(0.044)	(0.074)
Japan	-1.174***	-0.676***	-0.755***	-1.187***
	(0.056)	(0.052)	(0.054)	(0.073)
Korea	-0.526***	-0.238***	-0.220***	-0.158**
	(0.055)	(0.052)	(0.049)	(0.072)
United Kingdom	0.085**	-0.053	-0.127***	-0.260***
	(0.043)	(0.046)	(0.044)	(0.072)
Constant	4.513***	3.906***	4.688***	4.056***
	(0.075)	(0.075)	(0.071)	(0.103)
RMSE	1.157	1.146	1.132	1.616
Adjusted R^2	0.162	0.069	0.061	0.114
N	6089	6089	6089	6089

Notes: * < 0.1, ** < 0.05, *** < 0.01. Robust standard errors are in brackets. The reference groups are the richest quintile for income quintiles, age group 18-25 for age groups, rural residence for residence areas, and the United States for countries.

Table B.5. Inequality with changes in daily behavior

Variables	(Model 1) Change behavior	(Model 2) Wash hand	(Model 3) Wear mask	(Model 4) Eat fruit	(Model 5) Take vitamin	(Model 6) Do exercises	(Model 7) Video chat	(Model 8) Public trans.
Poorest quintile	-0.107***	-0.188***	-0.473***	-0.068**	-0.041	0.011	-0.147***	0.187***
	(0.015)	(0.042)	(0.064)	(0.031)	(0.029)	(0.041)	(0.050)	(0.049)
Second-poorest quintile	-0.055***	-0.089**	-0.186***	-0.026	-0.031	0.026	-0.096*	0.226***
	(0.014)	(0.042)	(0.063)	(0.032)	(0.030)	(0.041)	(0.051)	(0.049)
Middle-income quintile	-0.035***	-0.083**	-0.217***	-0.047	-0.113***	-0.001	-0.073	0.229***
	(0.013)	(0.041)	(0.061)	(0.031)	(0.027)	(0.040)	(0.050)	(0.047)
Second-richest quintile	0.006	-0.020	-0.085	-0.012	0.006	-0.013	0.046	0.088*
	(0.012)	(0.040)	(0.059)	(0.031)	(0.028)	(0.040)	(0.050)	(0.048)
Age group (26 to 35)	0.021	0.050	0.117	0.061	0.051	-0.108**	-0.104*	0.187***
	(0.015)	(0.050)	(0.076)	(0.038)	(0.035)	(0.049)	(0.059)	(0.063)
Age group (36 to 45)	0.013	-0.012	-0.117	0.025	0.033	-0.118**	-0.135**	0.186***
	(0.015)	(0.050)	(0.076)	(0.037)	(0.035)	(0.048)	(0.057)	(0.062)
Age group (46 to 55)	-0.032**	-0.009	-0.086	0.002	0.005	-0.209***	-0.194***	0.276***
	(0.016)	(0.048)	(0.076)	(0.036)	(0.033)	(0.047)	(0.055)	(0.060)
Age group (56 to 65)	-0.034**	0.112**	0.039	0.017	-0.048	-0.230***	-0.267***	0.181***
	(0.017)	(0.051)	(0.079)	(0.036)	(0.034)	(0.049)	(0.058)	(0.062)
Age group (66 to 75)	-0.055***	0.248***	0.206**	0.041	-0.013	-0.182***	-0.275***	0.181***
	(0.019)	(0.052)	(0.081)	(0.038)	(0.035)	(0.051)	(0.063)	(0.063)
Age group (Above 76)	-0.119***	0.304***	0.181	0.076	-0.031	-0.117*	-0.205***	0.229***
	(0.029)	(0.073)	(0.111)	(0.053)	(0.044)	(0.060)	(0.077)	(0.078)
Age group (Prefer not to say)	-0.483**	0.458	-0.055	0.398**	-0.327	0.400*	-0.677	0.649*
	(0.204)	(0.583)	(0.411)	(0.176)	(0.217)	(0.220)	(0.470)	(0.373)
Female	-0.046***	0.069***	-0.177***	0.075***	0.059***	0.032	-0.013	0.156***
	(0.009)	(0.026)	(0.040)	(0.020)	(0.018)	(0.026)	(0.032)	(0.030)
Urban	0.014	0.010	-0.000	0.045*	0.036	-0.052	-0.018	-0.253***
	(0.015)	(0.042)	(0.063)	(0.027)	(0.024)	(0.038)	(0.050)	(0.044)
Sub-urban	0.019	0.047	0.036	0.065**	0.078***	-0.019	0.057	-0.175***
	(0.015)	(0.041)	(0.061)	(0.026)	(0.023)	(0.037)	(0.049)	(0.042)
China	-0.053***	0.541***	0.280***	0.443***	0.276***	0.410***	0.182***	-0.582***
	(0.016)	(0.049)	(0.073)	(0.041)	(0.037)	(0.045)	(0.053)	(0.052)
Italy	0.028**	0.234***	1.048***	0.012	-0.060*	-0.195***	0.227***	-0.462***
	(0.013)	(0.043)	(0.075)	(0.035)	(0.033)	(0.046)	(0.068)	(0.052)
Japan	-0.081***	0.115***	-0.308***	-0.136***	-0.101***	-0.142***	-0.170***	-0.325***
	(0.016)	(0.043)	(0.069)	(0.028)	(0.025)	(0.037)	(0.042)	(0.048)
Korea	-0.005	0.344***	0.265***	0.131***	0.096***	-0.052	-0.044	-0.173***
	(0.014)	(0.045)	(0.076)	(0.037)	(0.034)	(0.045)	(0.047)	(0.049)
United Kingdom	0.014	0.054	-1.198***	-0.178***	-0.065**	-0.008	-0.015	-0.530***
	(0.014)	(0.040)	(0.065)	(0.032)	(0.029)	(0.039)	(0.056)	(0.053)
Constant	0.941***	0.518***	1.917***	0.156***	0.107**	0.163***	0.491***	-0.661***
	(0.022)	(0.066)	(0.102)	(0.049)	(0.042)	(0.061)	(0.078)	(0.076)
RMSE	0.337	1.007	1.542	0.752	0.699	0.985	1.221	1.155
Adjusted R^2	0.044	0.039	0.171	0.070	0.039	0.040	0.017	0.047
N	6089	6089	6089	6089	6089	6089	6089	6089

Notes: * < 0.1, ** < 0.05, *** < 0.01. Robust standard errors are in brackets. “Public trans.” stands for "taking public transportation". The reference groups are the richest quintile for income quintiles, age group 18-25 for age groups, rural residence for residence areas, and the United States for countries.

Table B.6. Tobit and ordered probit models for inequality with changes in prevention measures against COVID

Panel I: Tobit regression

Variables	Keep 4 ft. distance	Not touch face	Cover mouth when sneezing	Seek medical care
Poorest quintile	-0.862***	-0.642***	-0.924***	-0.503***
	(-0.155)	(-0.099)	(-0.161)	(-0.109)
Second-poorest quintile	-0.632***	-0.437***	-0.561***	-0.289***
	(-0.156)	(-0.1)	(-0.163)	(-0.11)
Middle-income quintile	-0.386**	-0.284***	-0.254	-0.384***
	(-0.154)	(-0.097)	(-0.161)	(-0.106)
Second-richest quintile	-0.024	-0.138	-0.052	-0.001
	(-0.157)	(-0.097)	(-0.162)	(-0.106)
Age group (26 to 35)	0.185	0.320***	0.168	-0.269**
	(-0.173)	(-0.112)	(-0.188)	(-0.13)
Age group (36 to 45)	0.354**	0.416***	-0.098	-0.242*
	(-0.172)	(-0.111)	(-0.183)	(-0.129)
Age group (46 to 55)	0.339**	0.322***	-0.015	-0.856***
	(-0.172)	(-0.11)	(-0.184)	(-0.127)
Age group (56 to 65)	0.631***	0.512***	0.134	-0.900***
	(-0.182)	(-0.116)	(-0.192)	(-0.131)
Age group (66 to 75)	1.009***	0.487***	0.237	-0.844***
	(-0.201)	(-0.122)	(-0.204)	(-0.138)
Age group (Above 76)	0.688**	0.491***	0.267	-0.824***
	(-0.268)	(-0.168)	(-0.281)	(-0.189)
Age group (Prefer not to say)	0.738	0.88	0.121	-1.461
	(-1.75)	(-1.182)	(-1.748)	(-1.087)
Constant	7.047***	4.852***	7.670***	5.138***
	(-0.257)	(-0.154)	(-0.277)	(-0.175)
Demographic characteristics	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Log likelihood	-4872	-6609	-4701	-8589
Pseudo R^2	0.077	0.034	0.031	0.042
N	6089	6089	6089	6089

Notes: * < 0.1, ** < 0.05, *** < 0.01. The reference groups are the richest quintile for income quintiles and age group 18-25 for age groups. The other demographic characteristics include gender and residence areas. For the Tobit regressions, we set the upper bound at 4 and lower bound at -4.

Panel I: Order probit regression

Variables	Keep 4 ft. distance	Not touch face	Cover mouth when sneezing	Seek medical care
Poorest quintile	-0.271***	-0.211***	-0.216***	-0.154***
	(-0.05)	(-0.045)	(-0.048)	(-0.047)
Second-poorest quintile	-0.235***	-0.164***	-0.148***	-0.089*
	(-0.049)	(-0.045)	(-0.048)	(-0.047)
Middle-income quintile	-0.152***	-0.132***	-0.064	-0.126***
	(-0.048)	(-0.043)	(-0.047)	(-0.046)
Second-richest quintile	-0.034	-0.055	0.0001	0.025

	(-0.048)	(-0.043)	(-0.047)	(-0.045)
Age group (26 to 35)	0.068	0.115**	-0.013	-0.096*
	(-0.055)	(-0.052)	(-0.055)	(-0.054)
Age group (36 to 45)	0.098*	0.158***	-0.042	-0.093*
	(-0.055)	(-0.051)	(-0.055)	(-0.053)
Age group (46 to 55)	0.167***	0.113**	-0.023	-0.306***
	(-0.055)	(-0.051)	(-0.055)	(-0.054)
Age group (56 to 65)	0.301***	0.190***	0.059	-0.343***
	(-0.058)	(-0.053)	(-0.057)	(-0.056)
Age group (66 to 75)	0.410***	0.174***	0.052	-0.317***
	(-0.063)	(-0.056)	(-0.061)	(-0.059)
Age group (Above 76)	0.353***	0.156**	0.012	-0.325***
	(-0.087)	(-0.077)	(-0.083)	(-0.082)
Age group (Prefer not to say)	0.199	0.933	0.018	-0.65
	(-0.553)	(-0.573)	(-0.531)	(-0.547)
Demographic characteristics	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Log likelihood	-6772	-8559	-7101	-8211
Pseudo R^2	0.076	0.023	0.025	0.039
N	6089	6089	6089	6089

Notes: * < 0.1, ** < 0.05, *** < 0.01. Standard errors are in the brackets. The reference groups are the richest quintile for income quintiles and age group 18-25 for age groups. The other demographic characteristics include gender and residence areas. Estimates are obtained using the heteroskedastic ordered probit models.

Table B.7. Tobit and ordered probit models for inequality with changes in prevention measures against COVID

Panel I: Tobit regression

Variables	Change behavior	Wash hand	Wear mask	Eat fruit	Take vitamin	Do exercises	Video chat	Public trans.
Poorest quintile	-0.107***	-0.187***	-0.554***	-0.068**	-0.04	0.012	-0.145***	0.190***
	(-0.014)	(-0.042)	(-0.081)	(-0.031)	(-0.029)	(-0.041)	(-0.052)	(-0.05)
Second-poorest quintile	-0.055***	-0.089**	-0.210***	-0.025	-0.031	0.026	-0.095*	0.227***
	(-0.014)	(-0.042)	(-0.082)	(-0.031)	(-0.029)	(-0.041)	(-0.052)	(-0.05)
Middle-income quintile	-0.035***	-0.083**	-0.256***	-0.047	-0.113***	-0.001	-0.069	0.235***
	(-0.014)	(-0.041)	(-0.079)	(-0.03)	(-0.028)	(-0.04)	(-0.05)	(-0.048)
Second-richest quintile	0.006	-0.02	-0.093	-0.012	0.006	-0.014	0.051	0.090*
	(-0.013)	(-0.04)	(-0.078)	(-0.03)	(-0.028)	(-0.039)	(-0.049)	(-0.047)
Age group (26 to 35)	0.021	0.049	0.125	0.060*	0.051	-0.109**	-0.109*	0.200***
	(-0.016)	(-0.049)	(-0.094)	(-0.036)	(-0.034)	(-0.048)	(-0.06)	(-0.057)
Age group (36 to 45)	0.013	-0.014	-0.155*	0.024	0.033	-0.119**	-0.137**	0.201***
	(-0.016)	(-0.048)	(-0.093)	(-0.036)	(-0.033)	(-0.047)	(-0.059)	(-0.057)
Age group (46 to 55)	-0.032**	-0.01	-0.103	0.002	0.005	-0.212***	-0.200***	0.297***
	(-0.016)	(-0.048)	(-0.093)	(-0.036)	(-0.033)	(-0.047)	(-0.059)	(-0.057)
Age group (56 to 65)	-0.034**	0.112**	0.05	0.016	-0.049	-0.232***	-0.273***	0.198***
	(-0.017)	(-0.05)	(-0.097)	(-0.037)	(-0.035)	(-0.049)	(-0.061)	(-0.059)
Age group (66 to 75)	-0.055***	0.247***	0.243**	0.041	-0.014	-0.183***	-0.282***	0.207***
	(-0.017)	(-0.053)	(-0.102)	(-0.039)	(-0.037)	(-0.052)	(-0.065)	(-0.062)
Age group (Above 76)	-0.119***	0.306***	0.238*	0.075	-0.031	-0.119*	-0.208**	0.251***
	(-0.024)	(-0.073)	(-0.141)	(-0.054)	(-0.051)	(-0.072)	(-0.09)	(-0.086)
Age group (Prefer not to say)	-0.483***	0.456	-0.43	0.398	-0.327	0.399	-0.683	0.68
	(-0.151)	(-0.456)	(-0.856)	(-0.338)	(-0.315)	(-0.446)	(-0.559)	(-0.534)
Constant	0.941***	0.520***	2.201***	0.157***	0.107**	0.164**	0.492***	-0.686***
	(-0.022)	(-0.066)	(-0.127)	(-0.049)	(-0.045)	(-0.064)	(-0.08)	(-0.077)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	-1999	-8743	-11088	-6941	-6516	-8624	-9976	-9695
Pseudo R^2	0.067	0.014	0.051	0.032	0.019	0.015	0.006	0.015
N	6089	6089	6089	6089	6089	6089	6089	6089

Notes: * < 0.1, ** < 0.05, *** < 0.01. Standard errors are in brackets. The reference groups are the richest quintile for income quintiles and age group 18-25 for age groups. The other demographic characteristics include gender and residence areas. For the Tobit regressions, we set the upper bound at 4 and lower bound at -4.

Panel II: Ordered probit regression

Variables	Change behavior	Wash hand	Wear mask	Eat fruit	Take vitamin	Do exercises	Video chat	Public trans.
Poorest quintile	-0.476***	-0.218***	-0.315***	-0.121**	-0.086	0.01	-0.170***	0.191***
	(-0.066)	(-0.045)	(-0.046)	(-0.051)	(-0.055)	(-0.047)	(-0.046)	(-0.046)
Second-poorest quintile	-0.266***	-0.106**	-0.115**	-0.049	-0.072	0.045	-0.117**	0.220***
	(-0.069)	(-0.045)	(-0.046)	(-0.051)	(-0.054)	(-0.047)	(-0.046)	(-0.046)
Middle-income quintile	-0.184***	-0.098**	-0.149***	-0.08	-0.204***	0.002	-0.084*	0.215***
	(-0.068)	(-0.043)	(-0.044)	(-0.049)	(-0.053)	(-0.045)	(-0.044)	(-0.044)
Second-richest quintile	0.03	-0.022	-0.058	-0.016	0.008	-0.001	0.03	0.084*
	(-0.07)	(-0.043)	(-0.044)	(-0.049)	(-0.052)	(-0.044)	(-0.044)	(-0.043)
Age group (26 to 35)	0.131	0.053	0.084	0.086	0.077	-0.127**	-0.076	0.158***
	(-0.081)	(-0.052)	(-0.053)	(-0.059)	(-0.063)	(-0.054)	(-0.053)	(-0.053)
Age group (36 to 45)	0.091	-0.005	-0.076	0.027	0.055	-0.134**	-0.110**	0.157***
	(-0.079)	(-0.052)	(-0.052)	(-0.058)	(-0.062)	(-0.053)	(-0.052)	(-0.052)
Age group (46 to 55)	-0.130*	0.001	-0.052	-0.005	0.027	-0.233***	-0.173***	0.223***
	(-0.077)	(-0.052)	(-0.052)	(-0.059)	(-0.062)	(-0.054)	(-0.053)	(-0.053)
Age group (56 to 65)	-0.141*	0.137**	0.052	0.04	-0.09	-0.279***	-0.238***	0.133**
	(-0.079)	(-0.054)	(-0.054)	(-0.061)	(-0.065)	(-0.056)	(-0.055)	(-0.055)
Age group (66 to 75)	-0.232***	0.284***	0.140**	0.067	0.009	-0.203***	-0.235***	0.124**
	(-0.081)	(-0.056)	(-0.057)	(-0.064)	(-0.069)	(-0.059)	(-0.057)	(-0.057)
Age group (Above 76)	-0.425***	0.349***	0.144*	0.124	-0.07	-0.148*	-0.187**	0.189**
	(-0.105)	(-0.078)	(-0.079)	(-0.089)	(-0.096)	(-0.082)	(-0.08)	(-0.081)
Age group (Prefer not to say)	-1.522**	0.466	-0.193	0.726	-0.87	0.599	-0.593	0.653
	(-0.595)	(-0.478)	(-0.466)	(-0.496)	(-0.571)	(-0.496)	(-0.492)	(-0.526)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	-2300	-7902	-8707	-5247	-4467	-7035	-7878	-7990
Pseudo R^2	0.055	0.015	0.061	0.039	0.029	0.020	0.011	0.020
N	6089	6089	6089	6089	6089	6089	6089	6089

Notes: * < 0.1, ** < 0.05, *** < 0.01. Standard errors are in brackets. The reference groups are the richest quintile for income quintiles and age group 18-25 for age groups. The other demographic characteristics include gender and residence areas. Estimates are obtained using the heteroskedastic ordered probit models.

Table B.8. Robustness check with a simpler definition of behavior changes

Variables	(Model 1) Change behavior	(Model 2) Wash hand	(Model 3) Wear mask	(Model 4) Eat fruit	(Model 5) Take vitamin	(Model 6) Do exercises	(Model 7) Video chat	(Model 8) Public trans.
Poorest quintile	-0.107***	-0.125***	-0.158***	-0.055***	-0.031*	0.005	-0.109***	0.120***
	(-0.015)	(-0.022)	(-0.02)	(-0.019)	(-0.017)	(-0.023)	(-0.024)	(-0.022)
Second-poorest quintile	-0.055***	-0.059***	-0.068***	-0.027	-0.022	0.036	-0.079***	0.124***
	(-0.014)	(-0.022)	(-0.02)	(-0.019)	(-0.017)	(-0.023)	(-0.024)	(-0.022)
Middle-income quintile	-0.035***	-0.051**	-0.079***	-0.044**	-0.060***	0	-0.061**	0.109***
	(-0.013)	(-0.021)	(-0.019)	(-0.018)	(-0.016)	(-0.023)	(-0.024)	(-0.021)
Second-richest quintile	0.006	-0.003	-0.031*	-0.017	-0.001	0.008	0.003	0.046**
	(-0.012)	(-0.021)	(-0.019)	(-0.018)	(-0.016)	(-0.023)	(-0.024)	(-0.021)
Age group (26 to 35)	0.021	0.027	0.055**	0.026	0.025	-0.056**	-0.03	0.025
	(-0.015)	(-0.026)	(-0.024)	(-0.022)	(-0.02)	(-0.027)	(-0.027)	(-0.025)
Age group (36 to 45)	0.013	0.01	-0.019	0.008	0.021	-0.057**	-0.046*	0.02
	(-0.015)	(-0.026)	(-0.024)	(-0.022)	(-0.02)	(-0.027)	(-0.027)	(-0.025)
Age group (46 to 55)	-0.032**	0.03	-0.024	-0.004	0.011	-0.099***	-0.077***	0.028
	(-0.016)	(-0.026)	(-0.024)	(-0.021)	(-0.019)	(-0.026)	(-0.026)	(-0.024)
Age group (56 to 65)	-0.034**	0.092***	0.03	0.023	-0.021	-0.129***	-0.108***	-0.013
	(-0.017)	(-0.027)	(-0.025)	(-0.022)	(-0.02)	(-0.027)	(-0.027)	(-0.025)
Age group (66 to 75)	-0.055***	0.172***	0.070***	0.029	0.018	-0.083***	-0.099***	-0.033
	(-0.019)	(-0.027)	(-0.025)	(-0.023)	(-0.02)	(-0.028)	(-0.03)	(-0.027)
Age group (Above 76)	-0.119***	0.203***	0.063*	0.044	-0.013	-0.070*	-0.086**	0.011
	(-0.029)	(-0.038)	(-0.035)	(-0.031)	(-0.027)	(-0.036)	(-0.04)	(-0.035)
Age group (Prefer not to say)	-0.483**	0.147	0.135	0.452**	-0.263	0.398*	-0.254	0.269
	(-0.204)	(-0.257)	(-0.168)	(-0.192)	(-0.202)	(-0.217)	(-0.289)	(-0.176)
Female	-0.046***	0.002	-0.057***	0.034***	0.029***	0.026*	-0.015	0.065***
	(-0.009)	(-0.014)	(-0.013)	(-0.012)	(-0.011)	(-0.014)	(-0.015)	(-0.014)
Urban	0.014	-0.001	0.011	0.031*	0.02	-0.019	0.005	-0.071***
	(-0.015)	(-0.022)	(-0.021)	(-0.017)	(-0.015)	(-0.021)	(-0.023)	(-0.021)
Sub-urban	0.019	0.016	0.03	0.035**	0.043***	-0.001	0.045**	-0.064***
	(-0.015)	(-0.022)	(-0.02)	(-0.016)	(-0.014)	(-0.021)	(-0.023)	(-0.02)
China	-0.053***	0.168***	0.132***	0.267***	0.194***	0.239***	0.103***	-0.355***
	(-0.016)	(-0.025)	(-0.023)	(-0.024)	(-0.022)	(-0.026)	(-0.027)	(-0.024)
Italy	0.028**	0.165***	0.223***	0.015	-0.057***	-0.104***	0.113***	-0.277***
	(-0.013)	(-0.024)	(-0.022)	(-0.021)	(-0.019)	(-0.026)	(-0.029)	(-0.023)
Japan	-0.081***	0.006	0.007	-0.073***	-0.075***	-0.084***	-0.125***	-0.190***
	(-0.016)	(-0.023)	(-0.023)	(-0.018)	(-0.014)	(-0.021)	(-0.021)	(-0.022)
Korea	-0.005	0.137***	0.086***	0.090***	0.042**	-0.047*	-0.050**	-0.161***
	(-0.014)	(-0.024)	(-0.024)	(-0.022)	(-0.018)	(-0.025)	(-0.024)	(-0.023)
United Kingdom	0.014	0.053**	-0.376***	-0.111***	-0.056***	-0.024	-0.012	-0.282***
	(-0.014)	(-0.024)	(-0.021)	(-0.02)	(-0.016)	(-0.024)	(-0.026)	(-0.023)
Constant	0.941***	2.379***	2.615***	2.122***	2.076***	2.080***	2.288***	1.733***
	(-0.022)	(-0.035)	(-0.033)	(-0.03)	(-0.025)	(-0.035)	(-0.036)	(-0.033)
RMSE	0.337	0.534	0.488	0.452	0.408	0.556	0.572	0.521
Adjusted R^2	0.044	0.03	0.139	0.071	0.052	0.043	0.028	0.056
N	6089	6089	6089	6089	6089	6089	6089	6089

Notes: * < 0.1, ** < 0.05, *** < 0.01. Robust standard errors are in brackets. "Public trans." stands for "taking public transportation". The reference groups are the richest quintile for income quintiles, age group 18-25 for age groups, rural residence for residence areas, and the United States for countries. Our dependent variables are behaviors changes with three values 1 to 3 that correspond to whether the post-outbreak behaviors have less frequency, the same frequency, or more frequency compared to the pre-outbreak behaviors.